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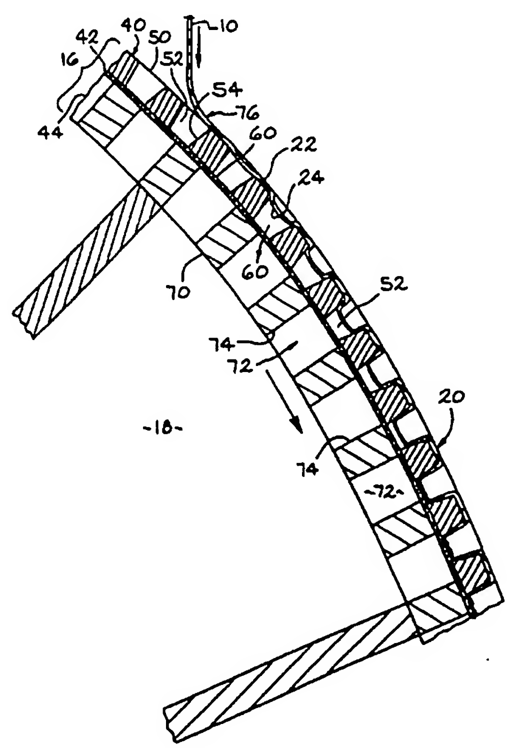
(54) Title: VAPOR PERMEABLE, LIQUID IMPERMEABLE FILMS FORMED USING A MULTI-LAYER SCREEN ASSEMBLY

(57) Abstract

A process for the manufacture of a three-dimensional vapor permeable, liquid impermeable film material (10), the substantially liquid impervious film, and an apparatus for making the film are disclosed. Successive portions of a film material are passed into contact with a continuous moving perforated member (16). The continuous moving perforated member has at least one outer apertured layer (40), at least one intermediate apertured layer (42) and at least one inner layer (44) having a plurality of openings (72) extending therethrough. Each of the layers are positioned coaxially with respect to each other and define a plurality of passageways through the moving perforated member. The film material is supplied onto a top surface (22) of the outer layer. A bottom surface (24) of the film material is subjected to a vacuum (18) which causes the portions of the film material to be pulled into apertures in the outer layer and against the intermediate layer. The vacuum is maintained for a period of time sufficient for a plurality of microtextured protuberances to be formed on the bottom surface of portions of the film material.



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DESCRIPTION

VAPOR PERMEABLE, LIQUID IMPERMEABLE FILMS FORMED USING A MULTI-LAYER SCREEN ASSEMBLY

Technical Field

The present invention relates to a method and apparatus for forming a vapor permeable, liquid impermeable continuous sheet or film of thermoplastic material using a multi-layer screen assembly and the films produced thereby.

Background of the Invention

Embossed plastic film or sheet material has come into wide spread use in many fields. One particularly large scale use of embossed thermoplastic sheet material is that of disposable articles such as disposable diapers, catamenial products, surgical dressings, disposable wearing apparel and the like. In order to fulfill the requirements established by the end uses of the embossed film, it is desirable that the film have suitable properties. It is important that the embossed thermoplastic film be soft and flexible and have a pattern and embossed depth in order to provide the desired cloth-like feel for the thermoplastic embossed material. In addition, for many uses it is desired that the embossed thermoplastic material have a low gloss surface in order to simulate woven cloth-like fabrics. Further, embossed thermoplastic materials must meet certain minimum physical specifications which are necessary in order that the films can be handled in high speed, automatic fabricating machines. These physical specifications include a desired modulus, tensile strength and impact strength.

In particular, embossed plastic films are especially useful as covers or barrier sheets or backsheets for absorbent articles. The backsheet on

the exterior of these articles prevents the absorbed liquid from leaking and striking through to an absorbent core. However, the liquid impervious backsheet prevents self drying of the absorbent core by any evaporation of the fluid held in the core material. The exterior liquid impervious backsheet makes the disposable article hot and clammy, and ultimately uncomfortable to wear. However, a liquid impervious backsheet is highly desirable to prevent fluid leaks through the backsheet. Therefore, it would be an advantage to have a breathable material which permits exchange of vapors and yet retains fluids as a liquid proof backsheet.

One type of film that is not only liquid impermeable, but also vapor permeable is a "microporous" thermoplastic film. The microporous structure of the film contains micropores connected through tortuous paths which extend from one exterior surface of the film to the other exterior surface of the film. One method to create microporous film involves perforating a previously made film by electrical discharge to form micropores. Other methods for making microporous films involve multi-step processes including resin compounding, casting and forming of the film, uniaxially or biaxially stretching, sintering and heatsetting or annealing of the film. In certain methods, leaching or solid particle removal is also required.

In various methods, the microporous film is formed by preparing a resin blend containing at least one type of filler material, drawing the resin blend into the film, stretching the drawn film, and heat setting or annealing the stretched film. In thermoplastic filler-containing films, the inorganic filler particles separate from the thermoplastic polymers during the stretching process. In various methods, the filler is removed from the film, while in other methods the filler is either allowed to remain intact within the film or is crushed under pressure to provide micropores in the film.

Micr porous films are very stiff and are not breathable without undergoing a stretching process. As the film is uniaxially or biaxially stretched, open cell structures or inner-connecting micropores are formed.

Another type of microporous film is a unfilled polyolefin-base microporous film which is typically a weak film formed by blending polymer powders with a pore forming agent to form a slurry and thereafter blowing or die casting a single phase structure. The film is air or chill roll quenched to form a two phase film. The pore forming agent, such as mineral oil, is partially miscible at extrusion temperatures but becomes immiscible at room temperature. The pore forming agent is then removed (by solvent extraction) to yield porosity in the film.

Other microporous films, while not using pore forming agents, are blends of polymers such as polypropylene and high density polyethylene which are drawn or stretched (such as cold rolling a crystalline film) thereafter hot stretching until the pores are formed and thereafter stabilizing by heatsetting. Another type of film comprises blends of incompatible or immiscible polymers which separate from each other during the stretching process. Still another type of film is made using a resin blend and solvents wherein polyolefins are dissolved at elevated temperatures in a solvent which forms blocks or pockets of solvent-containing cells when the heated polymer is stretched and cooled down. The solvents are then removed from the pockets in the polymer film.

Another type of film is a non-embossed film, containing an alphaolefin component in addition to polyethylene, which is made by stretching the film either uniaxially or bi-axially, reheating the film, and blowing gas through the heated formed film to enhance porosity.

In addition, non-polyolefin-based microporous films such as polytetrafluoroethylene and polyvinylidene difluoride microporous films

are pr duced using a sintering and stretching process, or solvent process, respectively.

However, the above methods for making microporous films have drawbacks, including the need for additional stretching equipment after a film formation step in order form pores in the film. Film stretching is known to weaken a film. Therefore, many such microporous films do not have sufficient water or liquid impermeability barrier properties and thus tend to leak.

Further, the liquid barrier properties of the film depend upon phenomena related to the contact area and wettability of the film including the nature of the film surface. The barrier properties of the film are maintained only as long as the liquid present exhibits a high contact angle on the surface of the film. Once the liquid enters the pores in the film the surface tension of the liquid and its contact angle on the walls of the pores in the film determine whether the pore structure will act as a barrier or as a sponge.

A major disadvantage of the prior art microporous films, which have been to this point used as backsheets, is that the prior art films are not sufficiently commercially acceptable. The microporous films have been expensive to produce due to the low production rate (the speed at which the film can be formed) and the special equipment required to stretch the film.

As a result of intensive investigations, the present inventors have achieved the present invention which provides a vapor-permeable, liquid impermeable film or sheet not having the disadvantages of the above described films or sheets.

The present invention provides a vapor permeable, liquid impermeable film and a method for making such film using a novel multi-layer screen assembly.

In the past, thermoplastic films having large apertures or macroperforations have been made using a stationary drum with an apertured screen or molding element mounted on the outer surface of the drum. The screen is adapted to rotate freely on the surface of the drum. A vacuum chamber is employed beneath the screen to create a pressure differential. As a thermoplastic material is passed over the screen, the pressure differential between the top surface of the film and the bottom surface of the film causes portions of the film to be pulled or flow into the apertures in the screen. A plurality of three-dimensional large apertures or macroperforations are formed in the film which correspond to the aperture pattern of the screen. One such method is described in Zimmerli, U.S. Patent No. 3,054,148. In addition, a variety of methods and apparatuses, including particular types of apertured screens, have been developed, including U.S. Patent Nos. 4,155,693, 4,252,516, 3,709,647, 4,151,240, 4,319,868, 4,388,056, 4,541,794, 4,636,161, 4,644,623 and Japanese Kokai Hei 01-144430. However, until the present invention, no one has used a rotating screen assembly to make non-perforated, vapor permeable, liquid impermeable three-dimensional thermoplastic films. Also, it was not until the present invention that any apertured screens have been contemplated as being useful for forming such breathable films.

It is therefore the primary object of the present invention to provide a vapor permeable, liquid impermeable three-dimensional film or sheet useful in disposable articles which are manufactured at low costs.

It is another object of the present invention to provide an improved method for forming a vapor permeable, liquid impermeable three-dimensional film material.

It is another object of the present invention to provide an improved apparatus for forming such vapor permeable, liquid impermeable three-dimensional film material.

It is still another object of the present invention to provide a vapor permeable, liquid impermeable article comprising a vapor permeable, liquid impermeable three-dimensional film, an absorbent core material, and a liquid pervious topsheet.

It is still another object of the present invention to provide a substantially liquid impervious article suitable for use as disposable absorbent products such as diapers, catamenial products, surgical dressings, disposable wearing apparel and the like.

Disclosure of the Invention

The present invention relates to a vapor permeable, liquid impermeable three-dimensional film produced using a deep pattern embossing process. According to a method of the present invention, a thermoplastic resin blend is simultaneously cast and embossed using a vacuum pressure differential across a perforated multi-layer screen assembly to form a three-dimensional, non-macroperforated, vapor permeable, liquid impermeable film. A suitable polymeric resin blend material is extruded onto a top surface of the multi-layer apertured screen assembly. The multi-layer screen comprises at least one inner layer, at least one intermediate layer and at least one outer layer. The inner layer comprises interconnected support members which define a number of openings between such support members. The inner layer acts to carry or support the intermediate layer. The intermediate layer is finely apertured and in preferred embodiments comprises a fine woven wire mesh material. The intermediate layer prevents aperturing or macroperforating of the film during the vacuum forming process. The intermediate layer provides a plurality of microprotuberances on the film and/or a microtextured pattern on the film. The outer layer comprises an apertured screen suitable for forming a plurality of three-dimensional protuberances, or macro embossed pattern, on the film. The outer

screen determines the embossed pattern and aesthetics of the film. The apertures in the outer layer are in communication with a number of the apertures in the intermediate layer which are in communication with a number of the openings in the inner layer, thus forming passageways through the outer layer, the intermediate layer and the inner layer.

The vacuum pulls a fluid (such as air) through a plurality of the passageways defined by the apertures in the outer layer, the apertures in the intermediate layer, and the openings in the inner layer. The vacuum pulls the film material against the top surface of the outer layer and into the apertures in the outer layer. The film is pulled against the intermediate layer. The film material is held under the vacuum pressure for a sufficient time to allow a plurality of three-dimensional protuberances (each having a plurality of microprotuberances thereon) to form on the bottom surface of the film.

In another aspect of the present invention, the three-dimensional vapor permeable, liquid impermeable film can be first embossed using a vacuum embossing process to form the protuberances with microprotuberances and then subjected to another embossing step to provide another deep embossed pattern.

The microporous films formed according to the present invention have acceptable moisture vapor transmission rates and high elongation rates. In preferred embodiments, the moisture vapor transmission rate ranges from about 200 to about 4,000 g/m^2/day at 100°F and 90% relative humidity. In preferred embodiments, the elongation ranges from about 400% to about 700%.

According to a preferred method of the present invention, a suitable polymeric resin blend is direct cast and embossed on a vacuum embossing screen in a single step. In a preferred embodiment, the vacuum differential pulls portions of the film material in a direction substantially perpendicular to the plane of the film rather than in the

machine direction and/or transverse machine direction. According to the present invention, the vapor permeable, liquid impermeable film can be produced at higher output rates and higher yields than other film processes.

According to another aspect of the present invention, an apparatus is provided for the manufacture of non-apertured, three-dimensional vapor permeable, liquid impermeable films or sheets. The apparatus comprises a multi-layer screen assembly or molding element which receives a web molten polymeric materials. The multi-layer screen assembly has at least one outer layer which defines a plurality of apertures which impart a desired embossed pattern of three-dimensional protuberances on a bottom surface of the film upon the film's contact with the outer layer and upon application of a fluid pressure differential or vacuum across the surfaces of the film. The multi-layer screen assembly further has at least one intermediate layer which defines a plurality of apertures having a greatly smaller cross-section or diameter than the cross-section or diameter of the apertures in the outer layer. The apertures in the intermediate layer impart a fine microtexture on each of the three-dimensional protuberances on the film. The intermediate layer prevents perforation of the film during the vacuum forming process. The multi-layer screen assembly has at least one inner layer which supports the intermediate layer. The inner layer has a plurality of support members which define a plurality of openings sufficient for a vacuum to be drawn through both the outer layer and intermediate layer.

It must be understood that various suitable layers can be utilized according to the method of the present invention. Furthermore, it is understood that the outer, intermediate and inner layers each can comprise more than one layer and that a number of layer combinations can be used to achieve the desired results.

Another aspect of the present invention pr vides a three-dimensional vapor permeable, liquid impermeable film having a planar surface and a three-dimensional surface. The three-dimensional surface is defined by a plurality of protuberances on the three-dimensional side of the film. Each three-dimensional protuberance has a plurality of microprotuberances or a microtextured pattern on a distal end of the protuberances.

In yet another aspect, the present invention comprises a composite article having a substantially vapor permeable, liquid impermeable three-dimensional film layer which prevents any liquid material from penetrating or leaking through the film layer material and which allows the evaporation of vapors through the film layer. The film layer has good elongation and is sufficiently tough to withstand high strain rates when the films are rapidly elongated.

Thus, composite articles made using the film material of the present invention provide highly desirable vapor permeable, liquid impermeable characteristics and also provide the advantage of the desirable tactile suede or cloth-like properties. The composite articles produced according to the present invention exhibit lower levels of noise when subjected to movement relative to a wearer's body. The composite article is sufficiently thin, soft and compliant and exhibits an attractive cloth-like tactile impression.

Brief Description of the Figures

Fig. 1 is a schematic diagram showing a process for making a vapor permeable, liquid impermeable three-dimensional film.

Fig. 2 is a partial cross-sectional view of a multi-layer screen assembly.

Fig. 3 is a cross-sectional view of a film being made on a multi-layer screen assembly.

Fig. 4 is a cross-sectional view of a portion of a three-dimensional film.

Fig. 5 is a scanning electron microphotograph (SEM) of a film formed using a multi-layer screen assembly showing the three-dimensional side at about a 45° angle.

Fig. 6 is a SEM photograph of a film formed using a multi-layer screen assembly showing the three-dimensional side at about a 45° angle.

Fig. 7 is a simplified greatly enlarged cross-sectional illustration of a vapor permeable, liquid impermeable film used in an absorbent article.

Fig. 8 is a simplified illustration of a protective gown using a vapor permeable, liquid impermeable three-dimensional film.

Fig. 9 is a simplified illustration of a protective facemask using a vapor permeable, liquid impermeable three-dimensional film.

Fig. 10 is a simplified cross-sectional illustration of a multi-layer structure having a vapor permeable, liquid impermeable three-dimensional film as at least one layer.

Fig. 11 is another simplified cross-section illustration of a multi-layer structure having a vapor permeable, liquid impermeable three-dimensional film as at least one layer.

Best Mode of Carrying Out Invention

One aspect of the present invention relates to a three-dimensional vapor permeable, liquid impermeable film. The present invention is useful for making monolithic vapor permeable, liquid impermeable films and microporous-enhanced vapor-permeable, liquid impermeable films.

In the monolithic vapor permeable, breathable films, the transmission of vapors and non-condensible gases occur mainly through activated diffusion. The permanent gases or vapors, present on the side of the film having the highest concentration of gases or vapors, first

dissolve in the surface of that side of the film. The gases or vapors diffuse across the film. Upon arriving at the opposite surface the gases or vapors desorb and enter the surrounding air space as a gas or vapor. The permeability is selective in monolithic films because permeability can be increased or decreased as the chemical and/or structural features of the polymers comprising the film are changed.

The liquid barrier properties of the film are provided by the density of the monolithic film which prevents the passage of condensed liquids regardless of the liquid's viscosity or surface tension. The liquid barrier properties are defined by burst strength, tensile properties or abrasion resistance of the film since no liquid flow is possible unless the film is ruptured. One advantage of monolithic films is that such films are free from any points of stress concentration, which points are created by the pores in a microporous film.

In certain embodiments, it is advantageous to use monolithic films which are tough enough to withstand high strain rates of being rapidly elongated to at least about 400% elongation. Still other advantages are that the monolithic films are very water resistant, surfactant insensitive, have selective permeability, high water entry pressure, variable water swelling, good tear strength, absolute microbe barrier, and excellent odor barrier.

Various resin materials which are suitable for use in the present invention and which can be extruded into a three-dimensional vapor permeable, liquid impermeable film include polyethylene (such as low density polyethylene) (LDPE), ethylene n-butyl acrylate (EBA) and ethylene methyl acrylate copolymers (EMA) and ethylene vinyl acetate (EVA).

Other useful resin materials comprise a copolyester thermoplastic elastomer such as a copolyetherester elastomer having a randomized hard-soft segment structure which is permeable to polar molecules such

as water but is resistant to penetration by non-polar hydrocarbons such as refrigerant gases.

Another useful resin material comprises thermoplastic polyurethane elastomers which are basically diisocynates and short chain diols (which form the basis of hard segments) and long chain diols (which form the basis of soft segments). Because the hard and soft segments are incompatible, the thermoplastic urethane elastomers exhibit two-phase structures which in turn cause the formation of domain microstructures.

Another useful resin material is a polyamide thermoplastic elastomer comprising hard and soft segments joined by amide linkages. These thermoplastic polyamide elastomers exhibit properties that depend upon the chemical composition of the hard (polyamide) and the soft (polyether, polyester or polyetherester) blocks as well as their segment lengths.

Still another useful resin material is a polymer/polymer composite combining polydimethyl siloxane and polytetrafluoroethylene (PTFE) in an inter-penetrating polymer network; that is, the film is a physical blend of the two polymers rather than a copolymer or new compound.

Other useful resin materials include copolyesters which are very permeable to water vapor and impermeable to liquid water. One suitable material is a copolyester of glycol (1,2-ethanediol) and a mixture of dicarboxylic acids made by the Eastman Company and is known as #14766.

In certain preferred embodiments, an ethylene methyl acrylate copolymer can be blended with one or more thermoplastic elastomers to improve the draw down and extrudability of the thermoplastic elastomer into a thin coating. The addition of the copolymer overcomes any draw down difficulties due to the high elastic nature of the thermoplastic elastomer.

In certain embodiments, specific film materials can comprise high moisture vapor transmission rate grade thermoplastic elastomers such as the Eastman Company's ECDEL® copolyester; DuPont's Hytrel® copolyester; Ato Chem's PEBAX® polyamide copolymer; DSM Engineering Plastics' Arnitel® copolyester; and Morton International and B. F. Goodrich's polyurethanes. In certain preferred embodiments, an ethylene methyl acrylate copolymer (EMAC®) can be blended with one or more thermoplastic elastomers to improve the draw down and extrudability of the thermoplastic elastomer to overcome any difficulties due to the high elastic nature of the thermoplastic elastomer.

Another suitable film material comprises a cold water resistant, hot water soluble polyvinyl alcohol (PVOH) coating material. The cold water insoluble polyvinyl alcohol film has a high moisture vapor transmission rate and is a very clear and flexible film which is insoluble in cold water.

Still another suitable film material comprises an alkaline soluble polymer which is permeable to water vapor and impermeable to liquid water. The alcohol film material is insoluble in water at normal pH and is soluble in solution with high pH.

According to another aspect of the present invention, a microporous-enhanced film comprising a resin blend containing a suitable amount of organic or inorganic filler is formed into a three-dimensional film using the process described below to form a vapor permeable, liquid impermeable material. In certain embodiments, the use of filler provides a film with desirable physical characteristics, particularly elongation and softness. It is important also to understand however that damage to a film by filler is dependent upon the concentration of filler in the thermoplastic filler-containing films. Therefore, finding an optimum level of filler provides a film with the optimum of physical properties.

Suitable resin materials which can be utilized with the process of the present invention include polyolefin resins such as low density

polyethylene, linear l w density polyethylene, high density polyethylene, polypropylene, ethylene-propylene copolymers and the like. Various inorganic fillers useful in the microporous films include silicone dioxide, titanium dioxide, calcium carbonate, magnesium carbonate, barium carbonate, magnesium sulfate, calcium sulfate, barium sulfate, magnesium oxide, silica including synthetic silica, aluminum hydroxide, alumina, talc, clay, kaolin, diatomaceous earth, glass powder, zeolite and the like. Various organic fillers can also be used such as sawdust, pulp powder, synthetic resin powders or synthetic fibers having a melting point above that of the resin blend used in the film.

In preferred embodiments, the mean particle size ranges from about 0.5 to about 15 microns and preferably from about 1.0 to about 10 microns. In embodiments wherein fibers are used, the diameter of the fiber preferably has a range within the particle ranges described above, although the length of the fiber typically greatly exceeds the cross-sectional diameter dimensions. It is especially preferred that the particles have a relatively uniform diameter such that when the particles are blended with a resin compound, the particles are somewhat uniformly dispersed through the resin blend.

It is to be understood that in certain embodiments, the vapor permeability can be further enhanced by adjusting the quantity and size of the filler particles in the microporous film. It is to be understood that the fillers are preferably present in the range from about 0 to about 25%, by weight, and in certain embodiments, from about 2 to about 15%, by weight, based on the percent by weight of the resin blend. It is to be understood that the addition of filler is controlled so that there is no excessive degradation of the film properties such as strength or elongation. It is to be understood that the addition of filler in certain embodiments, opens up some micropores in the film so that breathability of the film is further enhanced.

It is also with the contemplated scope of the pr sent invention that other useful materials such as lubricants, surfactants, anti-blocking agents and the like can be used in formulating the vapor permeable, liquid impermeable films.

The present invention provides a vapor permeable, liquid impermeable film without the need for extra processing steps such as stretching, tentering, orienting or heat setting of the film. The resin blend material is extruded or cast onto the multi-layer screen assembly. A vacuum pressure differential is applied to a lower surface of the film and forms a plurality of microtextured protuberances in the film. The film material is oriented in a direction away from the plane of the three-dimensional film (Z direction) rather than being oriented in the machine and/or transverse directions. As the microtextured protuberances are formed on the film, the film material is oriented in the Z direction rather than in the machine and transverse (X and Y) directions.

The three-dimensional film has a smooth or planar side and a textured or three-dimensional side defined by a plurality of protuberances. Each protuberance has a microtextured pattern on a distal end or cap of the protuberance. The cross-section of the distal ends of the protuberances is thinner than other cross-sectional areas of the film. The thinner cross-section of the distal ends of the protuberances increases the moisture vapor transmission rate of the film. Further, the microtextured pattern on the distal end provides a greater surface area for effective transfer of moisture vapor across the film. In preferred embodiments, the distal end of the protuberances is vacuum embossed onto to a multi-layer screen assembly film at a cross-sectional thickness of about 0.10 to about 1.0 mils, preferably about 0.15 to about .25 mils. The basis weight of the film preferably ranges from about 0.5 to about 5.0 mils. It is to be understood that the embossed thickness depends upon the screen geometry.

The present invention is useful to deeply emboss film in a highly controlled manner due to the multi-layer screen assembly. The screen assembly avoids aperturing of the film due to changes in web temperature and/or operating conditions of the film forming process.

In order to form the microtextured protuberances in the vapor permeable, liquid impermeable film material, the resin blend material is supplied at a sufficiently elevated temperature at a point of interface. The interface is the point at which the resin blend material comes into contact with the multi-layer screen assembly. The temperature of the film material is sufficiently elevated so that there is sufficient thermal energy supplied at the point of interface.

It is important to understand that since the viscosity of fluids correlates to the temperature of the fluids, the higher the temperature, the less viscous the fluid. Therefore, maintaining a high temperature (i.e., low viscosity) as the resin material contacts the multi-layer screen assembly is desired. This maintenance of thermal energy as, and after, the resin material contacts the multi-layer film assembly is controlled by two parameters of thermal dynamics, i.e., temperature and mass. The film material is supplied at a sufficiently elevated temperature and at a sufficient mass in order to form a plurality of microtextured protuberances. The film material is maintained at that sufficiently elevated temperature for a sufficient time for the protuberances and the microprotuberances or microtexture thereon to form.

The polymers useful as vapor permeable, liquid impermeable film materials have well-defined upper limits of temperature which can be manipulated before degradation of the polymer occurs. The well-defined thermal degradation limit of the polymer necessarily controls the amount of heat supplied to the extrusion process. The remaining parameter which can be controlled is the mass of the resin material extruded onto the multi-layer film assembly. The mass is controlled by regulating the

thickness of the resin material being extruded. In many end use applications, it is desired to have as thin a layer of film material as possible in order to have an acceptable vapor permeable, liquid impermeable film. However, if too thin an amount of resin material is extruded, the resin material quickly loses heat and cools too quickly, ruptures or tears. Therefore, the parameters of mass, temperature of the resin material, and the length of time at which the resin material is maintained at the proper temperature are controlled.

The thermal requirements of the extrusion process are further affected when the film material itself is a thermally sensitive material. The amount of thermal energy used to form the thermally sensitive film material is limited by the amount of thermal energy the protuberances and microprotuberances can tolerate without being damaged. Each three-dimensional microtextured protuberance (which causes the resulting film material to have a cloth-like or silky tactile feel) has an end or cap which is spaced apart from the plane of the film. The thickness of the film at these microtextured protuberances ends thereof is further reduced. These thin ends are especially sensitive to temperature and have the lowest mass point of the polymeric film and, as such, are the most critical to protect. It is important that the temperature and/or pressure applied during the film forming process not cause the ends of the microtextured protuberances to either melt and deform or to rupture. When the microtextured protuberances are melted or deformed, there is a less cloth-like tactile feeling to the three-dimensional film. When the microtextured protuberances are ruptured, the film loses its liquid impermeability.

Referring now to Figs. 1 and 4, a method of forming a vapor permeable, liquid impermeable three-dimensional film having a plurality of microtextured protuberances is generally shown. A film forming resin material 10 is dispensed from a slot die 12 from an opening 14 onto a

multi-layer screen assembly 16. The screen assembly is coaxially mounted as a drum or moving member 17 and a vacuum chamber 18 is preferably located within the drum 17. As best shown in Fig. 3, the film material 10 passes over the multi-layer screen assembly 16.

The vapor permeable, liquid impermeable resin material 10 is formed into a three-dimensional film 20 having a top, planar surface 22 and a bottom, three-dimensional surface 24. A plurality of protuberances 26 define the three-dimensional surface 24. Each protuberance 26 is defined by at least one sidewall 27 and a distal end or cap 28. A plurality of microprotuberances 29 which form a microtexture or pattern are present on each end 28.

Referring again to Fig. 1, in preferred embodiments of the present invention, the opening 14 is less than about 1 foot from the screen assembly 16. In especially preferred embodiments, the opening 14 can be approximately 2 to about 5 inches, or more preferably approximately 2 to about 3 inches from the screen assembly 16. The resin material 10 is dispensed onto the screen assembly 16 to form the film 20 which is then wound on a roll 30. In certain embodiments, it is contemplated that at least one other roller 32 such as an idler roller and/or cooling roll can be utilized with the present invention. It is also within the contemplated of the scope of the present invention that the film can be subjected to other treatments including, for example, a corona treatment.

Referring now to Figs. 2 and 3, the multi-layer screen assembly 16 comprises at least one outer layer 40, at least one intermediate layer 42 and at least one inner layer 44. Each layer 40, 42 and 44 has a substantially cylindrical shape and the layers 40, 42 and 44 are positioned coaxially with respect to each other. It should be understood that according to the present invention, each of the first, second and third layers of the screen assembly 16 can each comprise more than one

layer. F r ease f illustration herein, each layer is depicted as having one layer.

Referring now to Figs. 2 and 3 in particular, the outer layer 40 has a patterned surface 50 which is highly perforated with a plurality apertures 52, each of which are defined by sidewalls 54. The apertured surface 50 provides the protuberances or macro embossed pattern on the thermoplastic film. The apertures 52 extend through the outer layer 40 to allow a fluid such as air to pass through the perforations 52 in the surface 50 of the outer layer 40. In the embodiment shown in Figs. 1 and 3, the outer layer 40 may be formed as an integral unit in a shape of a cylinder and be adapted to slide over the intermediate layer 42 and inner layer 44. However, for ease of illustration, in Fig. 2, the layers 40, 42 and 44 are drawn in a flat or planar dimension to show the geometry and relative sizes of the apertures and/or openings in the layers 40, 42 and 44.

The intermediate layer 42 defines a plurality of apertures 60 having a cross-section or diameter greatly smaller than the cross-section or diameter of the apertures 52 in the outer layer 40. The intermediate layer 42 provides a plurality of microprotuberances 29 or microtextured pattern on the end 29 of the protuberances 28. The intermediate layer 42 prevents aperturing or macroperforating of the film during the vacuum forming process.

In the embodiment shown in Figs. 2 and 3, the intermediate layer 42 comprises a screen material formed by weaving a plurality of wires 60 which defines a plurality of perforations 62. The intermediate layer 42 is sufficiently perforated such that a vacuum pressure differential can be formed across the intermediate layer 42. In certain embodiments, the intermediate layer 42 comprises a woven wire material and can be made of any suitable metal material. In one preferred embodiment, the woven wire material comprises a 180 x 180 x .0018 inches stainless steel

material. In certain preferred embodiments, the use of a metallic mesh for the intermediate layer improves the heat transfer from the film material, thereby quickly cooling the film and ultimately improving the film production rates. Further, the microtextured ends or caps 28 of the film improve the visual appearance of film by reducing the gloss of the film.

The inner layer 44 provides a support for the intermediate layer 42. The inner layer 44 comprises a plurality of support members 70 which, in preferred embodiments, are interconnected. The support members 70 define a plurality of openings 72, each having at least one sidewall 74. The openings 72 extend through the inner layer 44 to allow the vacuum pressure differential to be pulled through the openings 72.

In a preferred embodiment, the intermediate layer 42 and inner layer 44 are comprised of compatible materials such that the intermediate layer can be permanently affixed or bonded to the inner layer. In one preferred embodiment, when the intermediate layer and inner layer comprise stainless steel, the intermediate layer can be diffusion bonded to the inner layer.

The thickness of each layer of the screen assembly 16 depends on the type of film material being formed. In preferred embodiments, the apertures 52 on the outer layer 40 have predetermined dimensions such that when the protuberances 26 are formed, the length of the sidewalls 27 and the dimension or diameter of the end 28 are in about a 0.2 to about 3.0 ratio; that is, the ratio of the depth of the protuberance to the diameter of the protuberance can range from about 0.2 to about 3.0 and, in certain embodiments, preferably about 1.8:1. It is to be understood that both the thickness of the film and the melt index of the film have an impact on the ability to draw a three-dimensional microtextured protuberant film. It is to be understood that films having a higher melt index are easier to draw.

The support members 70 f the inner layer 44 provide a sufficient surface area for the intermediate layer 42 to be supported by the inner layer 44. The inner layer 44 does not cause apertures in the film. The openings 72 of the inner layer 44 allow a sufficient volume of air to be moved through a plurality of passageways (shown by arrows in Fig. 3) in the screen assembly 16. The openings 72 in the inner layer 44 do not match the apertured pattern of the outer layer 40 in most embodiments.

In certain embodiments, the intermediate layer 42 is physically adhered or bonded to the inner layer 44 to provide strength to the intermediate layer 42 such that the intermediate layer 42 has a long useful life in producing films of the present invention.

It is also contemplated that all three layers can be diffusion bonded together. Alternatively, an interference fit (not shown) can be used to lockingly engage all three layers so that all three layers coaxially rotate at the same speed.

In preferred embodiments, the film material 10 is extruded onto the top surface 50 of the outer layer 40 at an interface point 76 just prior to the application of the vacuum pressure to the film material 10. The vacuum chamber 18 is utilized to create a vacuum or pressure differential between the top surface 22 and the bottom surface 24 of the film material 10. The vacuum pressure is sufficient to pull the film material 10 into apertures 52 in the outer layer 40 while maintaining the integrity of the film material 10 and not causing any perforations or rupturing of the film material 10.

The vacuum pulls fluid, preferably air, which is present in the apertures 52 of the outer layer 40. The removal of air from the apertures 52 causes a plurality of portions of the film material 10 to be pulled into the apertures 52. The vacuum is applied such that sufficient pressure pulls the film material 10 into the apertures 52 and against the

intermediate layer 42 with ut perforating or tearing holes in the film material 10.

Fig. 4 shows one detailed embodiment of one microtextured protuberance 26 of vapor permeable, liquid impermeable film 20. Portions of the film 20 forming the sidewalls 27 and the end 28 of the protuberance 26 taper or narrow in a direction away from the planar surface 22 of the film 20. In certain embodiments, each end 28 has a thinner cross-section than the remaining planar portions of the film 20. The thinner cross-section of the end 28 provides greater permeability to the vapor permeable, liquid impermeable film 20. The end 28 is formed as the film material 20 is pulled against the intermediate layer 42. A plurality of microprotuberances 29 form a microtextured pattern on the end 28. The plurality of microprotuberances 29 on the protuberances 26 provide a pleasing texture and low-gloss visual appearance to the three-dimensional film 20.

According to the present invention, by varying the rate of speed of rotation of the screen assembly as it forms the film, the amount of vacuum pressure applied to the film material, and the temperature level of the film material, it is now possible to form a thin vapor permeable, liquid impermeable three-dimensional film. In certain embodiments, the addition of a suitable filler material further enhances the permeability of the film.

According to the present invention, the thermoplastic material can be extruded as a thin layer such that the film does not have a "stiff" plastic feeling. Rather, the film is soft and has cloth-like tactile qualities. A further advantage is that a substantially thinner layer (and consequently, less amount) of film material is needed. This decrease results in great cost savings. Also, a thinner film is more permeable to vapors. Further, low cost film materials such as polyethylene films and

other examples, including polyethylene and other polymeric materials can be used to form the vapor permeable, liquid impermeable film.

Figs. 5 and 6 are scanning electron microphotographs of three-dimensional vapor permeable, liquid impermeable film materials produced according to the present invention. The film is highly embossed and has a thinner cross-section at the ends of the protuberances than at other cross-sections of the film. The film in Figs. 5 and 6 comprises a resin blend of 72.5.%, by weight, linear low density polyethylene, 10%, by weight, low density polyethylene, 7.5.%, by weight, 8.5 microns mean particle size diatomaceous earth, 5.0%, by weight, titanium dioxide and 5.0%, by weight, polypropylene. The resin blend was melted and extruded at 110 ft./min as a film from a sheet molder upon a 12.927" outside diameter cylindrical rotating molding element consisting of an inner layer (0.60" thick, 30% open area, 0.060" diameter holes), a middle fine wire mesh layer (180 x 180 mesh, 47% open area), and a patterned outer layer (0.024" thick, 73% open area, 0.045" diameter holes) under 5" Hg relative vacuum. A non-apertured highly embossed film with a basis weight of 27 g/m^2 was produced. The water vapor transmission rate was 809 g/m^2/day (100°F, 90% relative humidity).

It is contemplated that various articles can be formulated using the film and method of the present invention. For example, Fig. 7 shows a section of a disposable product 80, generally comprising a vapor permeable, liquid impermeable film 82, an absorbent core 84, and a fluid pervious topsheet 86. The film 82 comprises a planar surface 92 and a three-dimensional surface 94. The three-dimensional surface 94 defines a plurality of protuberances 96 each having at least one sidewall 98 and end 99. Each end 99 defines a plurality of microprotuberances 100. The absorbent core 84 is placed between the vapor permeable, liquid impermeable film 82 and the fluid pervious topsheet 86. In the embodiment shown in Fig. 7, the fluid pervious topsheet 86 comprises

a three-dimensi nal surface having a planar surface 102 and a three-dimensional surface 104 having a plurality of apertures 106, each of which are defined by at least one sidewall 108. It is contemplated that further layers such as a nonwoven layer (not shown) can be applied to the planar surface 102 of the fluid pervious topsheet 86.

The vapor permeable, liquid impermeable material is useful in providing a breathable structure that has good resistance to penetration to fluids and more particularly liquids. The vapor permeable, liquid impervious material is especially useful in the applications where fluid is splashed or sprayed onto the material and the material provides resistance to the direct path through fluid. This fabric can be utilized in the medical fields, hazardous waste fields or other areas where people are interested in being protected from spilled or sprayed fluids.

Fig. 8 shows a protective gown 110 and Fig. 9 shows a protective facemask 112 that can be made using the vapor permeable, liquid impermeable material as one layer of the gown and/or mask. It is contemplated that at least one additional layer of material comprising, for example, at least one layer of nonwoven material may be adhered to the film of the present invention. It is also within the contemplated scope of the present invention that other disposable articles, such as gloves and the like, can be made using the films of the present invention.

Fig. 10 shows another structure having the film 20 of Fig. 4 adjacent at least one layer 120 such as a paper cover stock that is lightweight and also highly breathable.

Fig. 11 is a further embodiment showing a film 20 shown in Fig. 4 adjacent at least two layers 122 and 124, such as paper cover 124 stock material.

It is to be understood that in various embodiments the breathable or vapor permeable films have high moisture vapor transmission rates

preferably ab ut 200 to about 4,000 g/m^2/day testing a 1 mil film (thickness by weight) tested at 100°F and 90° relative humidity.

It is to be understood that in other embodiments useful articles can be formulated having desirable moisture vapor transmission rates particularly suited to the end use needs required for that particular article.

It is further understood that the vapor permeable, liquid impermeable three-dimensional material can be present as an outermost layer, an intermediate layer or as an innermost layer in a multi-layer breathable structure. Those skilled in the art will readily recognize the advantages of positioning the vapor permeable, liquid impermeable material as such layers in order to take advantage of the desirable properties, including the moisture vapor transmission rate, toughness or durability and aesthetic characteristics of the film.

Various other articles can be formulated using the method of the present invention. While particular embodiments of the present invention have been illustrated and described, it will be obvious to those skilled in the art that various changes and modifications can be made without parting from the spirit and scope of the invention and it is intended to cover in the claims herein all such modifications that are within the scope of this invention.

CLAIMS:

1. A method for the manufacture of a three-dimensional vapor permeable, liquid impermeable film material comprising:

(a) passing successive portions of a film material having a top surface and a bottom surface into contact with a continuous moving perforated member, the perforated member comprising

i) at least one outer layer having a plurality of apertures extending therethrough, each aperture defining a predetermined cross-section or diameter;

ii) at least one intermediate layer having a plurality of apertures extending therethrough, each aperture in the intermediate layer having a smaller cross-section or diameter than the diameter defined by the apertures in the outer layer; and

iii) at least one inner layer having a plurality of support members which define a plurality of openings extending therethrough, each opening defining a predetermined cross-section or diameter greater than the cross-section or diameter of the apertures of the intermediate layer, whereby the apertures in the outer layer, the apertures in the intermediate layer and the openings in the inner layer define a plurality of passageways through the moving perforated member;

(b) subjecting the bottom surface of the film material to the action of a vacuum;

(c) maintaining the vacuum for a period of time sufficient for portions of the film material to be pulled into the apertures in the

outer layer such that a plurality of three-dimensional protuberances are formed; each protuberance being defined by at least one sidewall and an end, the end of each protuberance being pulled against the intermediate layer, wherein a plurality of microprotuberances are formed on the end of each protuberance; and

(d) continuously removing the three-dimensional vapor permeable, liquid impermeable film material from the moving perforated member.

2. The method of claim 1, wherein the film has a moisture vapor transmission rate of at least about 200 g/m^2/day at 100°F and 90% relative humidity.

3. The method of claim 1, wherein the film material is extruded onto the moving perforated member at an elevated temperature.

4. The method of claim 1, wherein the film material is delivered from an extrusion member, the extrusion member being located about 2 to about 5 inches from the top surface of the moving perforated member.

5. The method of claim 1, wherein the film material comprises a monolithic film.

6. The method of claim 1, wherein the film material comprises a microporous film.

7. The method of claim 1, wherein the film material comprises an ethylene methyl acrylate copolymer.

8. The method of claim 1, wherein the film material comprises a resin blend of linear low density polyethylene, low density polyethylene, polyproylene and at least one type of filler material.

9. The method of claim 3, wherein the moving perforated member cools the film material as the film material is extruded onto the moving perforated member.

10. The method of claim 1, wherein the film material is extruded at a thickness of about 0.10 mils to about 5.0 mils, by weight.

11. The method of claim 1, wherein the distal end of the protuberance has a thickness or cross-section which is less than a cross-section of the remaining portions of the three-dimensional film.

12. A continuous method for forming a substantially liquid impervious composite material comprising a three-dimensional film having a top, planar surface and a bottom, three-dimensional surface and a plurality of protuberances extending therethrough, the method comprising the steps of:

(a) continuously bringing successive portions of the film material into contacting relation with a continuous moving perforated member comprising at least one outer layer, at least one intermediate layer and at least one inner layer;

(b) applying the film material in the direction of travel of the moving perforated member, the film material having sufficient heat and mass flux such that the film material substantially conforms to at least the outer layer of the moving perforated member;

(c) supplying a vacuum to the bottom surface of the film material, the vacuum being sufficient to pull portions of the film material

int apertures in the uter layer and against the intermediat layer such that three-dimensional protuberances are formed, the vacuum being controlled such that no perforations or apertures are formed in the film material; and

(d) removing the film from the moving member.

13. An apparatus for continuously forming a three-dimensional vapor permeable, liquid impermeable film material comprising:

(a) a continuous moving member comprising

i) at least one outer layer having a plurality of apertures extending therethrough;

ii) at least one intermediate layer having a plurality of apertures extending therethrough; and

iii) at least one inner layer having a plurality of support members which define a plurality of openings extending therethrough; wherein the apertures in the outer layer, the apertures in the intermediate layer and the openings in the inner layer define a plurality of passageways through the moving member;

(b) means for creating a vacuum through at least a portion of the passageways in the moving member;

(c) means for continuously bringing successive portions of the film material in contacting relationship with the moving member; and

(d) means for continuously removing the film material from the moving member.

14. The apparatus of claim 13, wherein the vacuum is sufficient to cause portions of the film material to be pulled into at least a plurality of the apertures in the outer layer and against the intermediate layer.

15. The apparatus of claim 13, wherein each aperture extending through the outer layer has a first, predetermined cross-section or diameter, each aperture extending through the intermediate layer having a second, predetermined cross-section or diameter; and each opening in the inner layer having a third predetermined cross-section or diameter, wherein the apertures in the intermediate layer have a smaller cross-section or diameter than the diameters defined by the apertures in the outer layer, and wherein the openings in the inner layer have a predetermined cross-section or diameter greater than the cross-section or diameter of the outer layer.

16. The apparatus of claim 13, including a means for heating the film material prior to dispensing the film material onto the continuous moving member.

17. The apparatus of claim 16, wherein the heated film material is dispensed onto the continuous moving member at a distance of about to 2 to about 5 inches above a top surface of the moving member.

18. A three-dimensional, vapor permeable, liquid impermeable film material which has a moisture vapor transmission rate of at least about 200 $g/m^2/day$ at 100°F and 90% relative humidity.

19. The film material of claim 18, wherein the film material comprises a monolithic film.

20. The film material of claim 18, wherein the film material comprises an ethylene methyl acrylate copolymer.

21. The film material f claim 18, wherein the film material comprises a microporous film.

22. The film material of claim 18, wherein the film material comprises a resin blend of linear low density polyethylene, low density polyethylene, polypropylene, and at least one type of filler material.

23. The film material of claim 18, wherein portions of the film material are about 0.10 mils to about 5.0 mils in thickness, by weight.

24. An absorbent article comprising the film material of claim 18, an absorbent core and a fluid pervious topsheet.

25. The absorbent article of claim 24, wherein the absorbent article is a disposable diaper.

26. The absorbent article of claim 24, wherein the absorbent article is an incontinent pad.

27. The absorbent article of claim 24, wherein the absorbent article is a catamenial product.

28. An article of protective clothing wherein at least one layer is the film material of claim 18.

AMENDED CLAIMS
[received by the International Bureau on 18 March 1996 (18.03.96); original claims 1,12 and 13 amended; remaining claims unchanged (6 pages)]

1. A method for the manufacture of a three-dimensional vapor permeable, liquid impermeable film material comprising:

(a) passing successive portions of a film material having a top surface and a bottom surface into contact with a continuous moving perforated member, the perforated member comprising

i) at least one outer layer having a plurality of apertures extending therethrough, each aperture defining a predetermined cross-section or diameter;

ii) at least one intermediate layer having a plurality of apertures extending therethrough, each aperture in the intermediate layer having a smaller cross-section or diameter than the diameter defined by the apertures in the outer layer; and

iii) at least one inner layer having a plurality of support members which define a plurality of openings extending therethrough, each opening defining a predetermined cross-section or diameter greater than the cross-section or diameter of the apertures of the intermediate layer, whereby the apertures in the outer layer, the apertures in the intermediate layer and the openings in the inner layer define a plurality of passageways through the moving perforated member; wherein the intermediate layer is diffusion bonded to the inner layer;

(b) subjecting the bottom surface of the film material to the action of a vacuum;

(c) maintaining the vacuum f r a period of time sufficient for portions of the film material to be pulled into the apertures in the outer layer such that a plurality of three-dimensional protuberances are formed, each protuberance being defined by at least one sidewall and an end, the end of each protuberance being pulled against the intermediate layer, wherein a plurality of microprotuberances are formed on the end of each protuberance; and

(d) continuously removing the three-dimensional vapor permeable, liquid impermeable film material from the moving perforated member.

2. The method of claim 1, wherein the film has a moisture vapor transmission rate of at least about 200 $g/m^2/day$ at 100°F and 90% relative humidity.

3. The method of claim 1, wherein the film material is extruded onto the moving perforated member at an elevated temperature.

4. The method of claim 1, wherein the film material is delivered from an extrusion member, the extrusion member being located about 2 to about 5 inches from the top surface of the moving perforated member.

5. The method of claim 1, wherein the film material comprises a monolithic film.

6. The method of claim 1, wherein the film material comprises a microporous film.

7. The method of claim 1, wherein the film material comprises an ethylene methyl acrylate copolymer.

8. The method of claim 1, wherein the film material comprises a resin blend of linear low density polyethylene, low density polyethylene, polyproylene and at least one type of filler material.

9. The method of claim 3, wherein the moving perforated member cools the film material as the film material is extruded onto the moving perforated member.

10. The method of claim 1, wherein the film material is extruded at a thickness of about 0.10 mils to about 5.0 mils, by weight.

11. The method of claim 1, wherein the distal end of the protuberance has a thickness or cross-section which is less than a cross-section of the remaining portions of the three-dimensional film.

12. A continuous method for forming a substantially liquid impervious composite material comprising a three-dimensional film having a top, planar surface and a bottom, three-dimensional surface and a plurality of protuberances extending therethrough, the method comprising the steps of:

(a) continuously bringing successive portions of the film material into contacting relation with a continuous moving perforated member comprising at least one outer layer, at least one intermediate layer and at least one inner layer; wherein the intermediate layer is diffusion bonded to the inner layer;

(b) applying the film material in the direction of travel of the moving perforated member, the film material having sufficient heat and mass flux such that the film material substantially conforms to at least the outer layer of the moving perforated member;

(c) supplying a vacuum to th bottom surface of the film material, the vacuum being sufficient to pull portions of the film material into apertures in the outer layer and against the intermediate layer such that three-dimensional protuberances are formed, the vacuum being controlled such that no perforations or apertures are formed in the film material; and

(d) removing the film from the moving member.

13. An apparatus for continuously forming a three-dimensional vapor permeable, liquid impermeable film material comprising:

(a) a continuous moving member comprising

i) at least one outer layer having a plurality of apertures extending therethrough;

ii) at least one intermediate layer having a plurality of apertures extending therethrough; and

iii) at least one inner layer having a plurality of support members which define a plurality of openings extending therethrough; wherein the intermediate layer is diffusion bonded to the inner layer; and, wherein the apertures in the outer layer, the apertures in the intermediate layer and the openings in the inner layer define a plurality of passageways through the moving member;

(b) means for creating a vacuum through at least a portion of the passageways in the moving member;

(c) means for continuously bringing successive portions of the film material in contacting relationship with the moving member; and

(d) means for continuously removing the film material from the moving member.

14. The apparatus of claim 13, wherein the vacuum is sufficient to cause portions of the film material to be pulled into at least a plurality of the apertures in the outer layer and against the intermediate layer.

15. The apparatus of claim 13, wherein each aperture extending through the outer layer has a first, predetermined cross-section or diameter, each aperture extending through the intermediate layer having a second, predetermined cross-section or diameter; and each opening in the inner layer having a third predetermined cross-section or diameter, wherein the apertures in the intermediate layer have a smaller cross-section or diameter than the diameters defined by the apertures in the outer layer, and wherein the openings in the inner layer have a predetermined cross-section or diameter greater than the cross-section or diameter of the outer layer.

16. The apparatus of claim 13, including a means for heating the film material prior to dispensing the film material onto the continuous moving member.

17. The apparatus of claim 16, wherein the heated film material is dispensed onto the continuous moving member at a distance of about to 2 to about 5 inches above a top surface of the moving member.

18. A three-dimensional, vapor permeable, liquid impermeable film material which has a moisture vapor transmission rate of at least about 200 $g/m^2/day$ at 100°F and 90% relative humidity.

19. The film material of claim 18, wherein the film material comprises a monolithic film.

20. The film material of claim 18, wherein the film material comprises an ethylene methyl acrylate copolymer.

21. The film material of claim 18, wherein the film material comprises a microporous film.

22. The film material of claim 18, wherein the film material comprises a resin blend of linear low density polyethylene, low density polyethylene, polypropylene, and at least one type of filler material.

23. The film material of claim 18, wherein portions of the film material are about 0.10 mils to about 5.0 mils in thickness, by weight.

24. An absorbent article comprising the film material of claim 18, an absorbent core and a fluid pervious topsheet.

25. The absorbent article of claim 24, wherein the absorbent article is a disposable diaper.

26. The absorbent article of claim 24, wherein the absorbent article is an incontinent pad.

27. The absorbent article of claim 24, wherein the absorbent article is a catamenial product.

28. An article of protective clothing wherein at least one layer is the film material of claim 18.

STATEMENT UNDER ARTICLE 19

The amendment, as provided in the amended claims discloses, in part, a method for the manufacture of a three-dimensional vapor permeable, liquid impermeable film material, an apparatus for forming the three-dimensional vapor permeable, liquid impermeable film material and the three-dimensional thermoplastic film itself. It was not until the present invention that any apertured screens were contemplated as being useful for forming such breathable films. The present invention, as described in the amended claims, relates to at least one intermediate layer which is diffusion bonded to an inner layer for forming a highly breathable film.

The present invention is patentably distinct from screens fabricated for producing selectively apertured films; that is, screens wherein some areas of the film are apertured while other areas are not. Rather, the present invention produces apertured, highly breathable films.

The present invention is an improvement over screens wherein a polyester cloth was used as a restrictor material and which polyester cloth was adhesively bonded to a support screen. The present invention provides a more rigid and durable screen by reciting that an intermediate screen is diffusion bonded to the inner layer. The diffusion bonding provides support and reduces any slipping or selective rotating of the layers of screens.

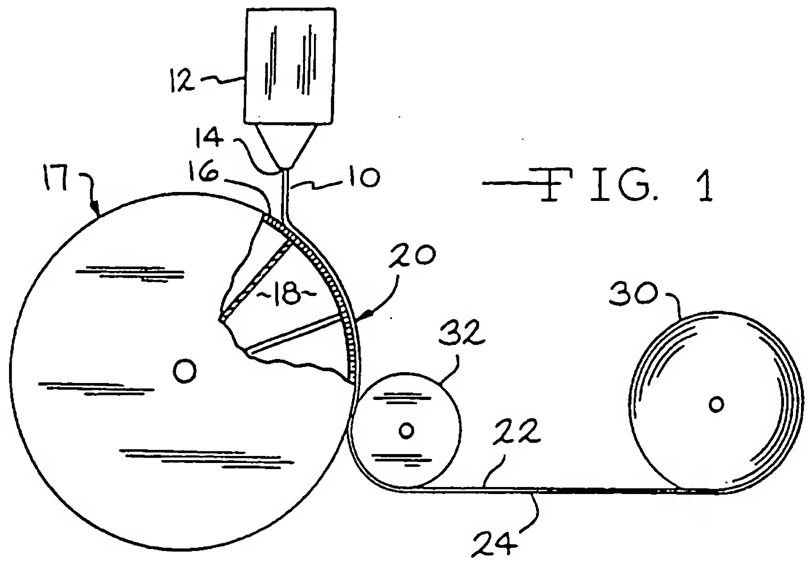

FIG. 1

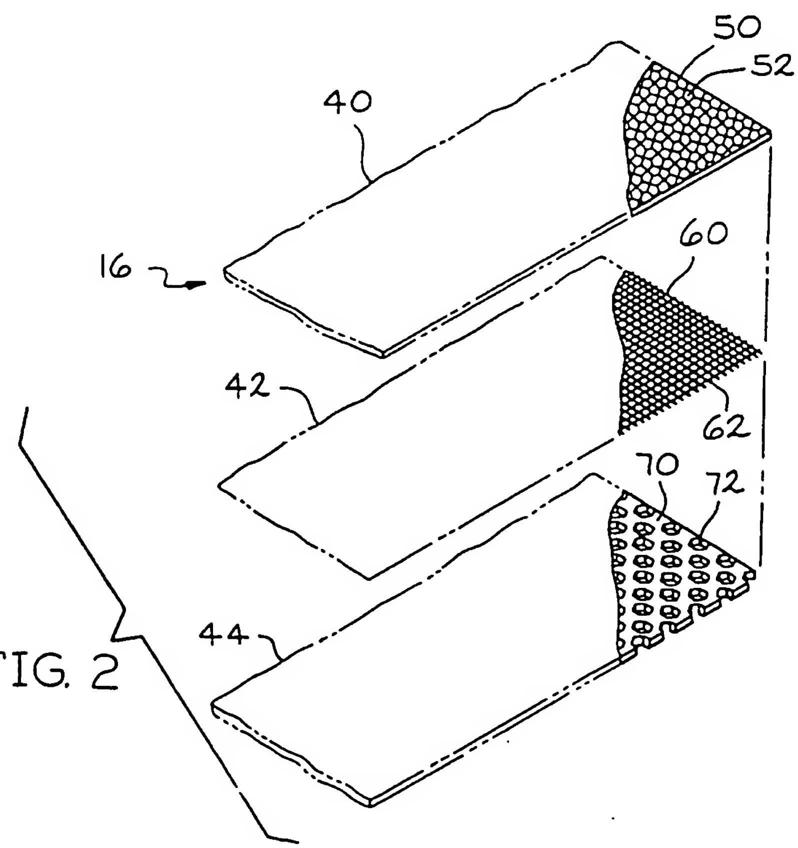

FIG. 2

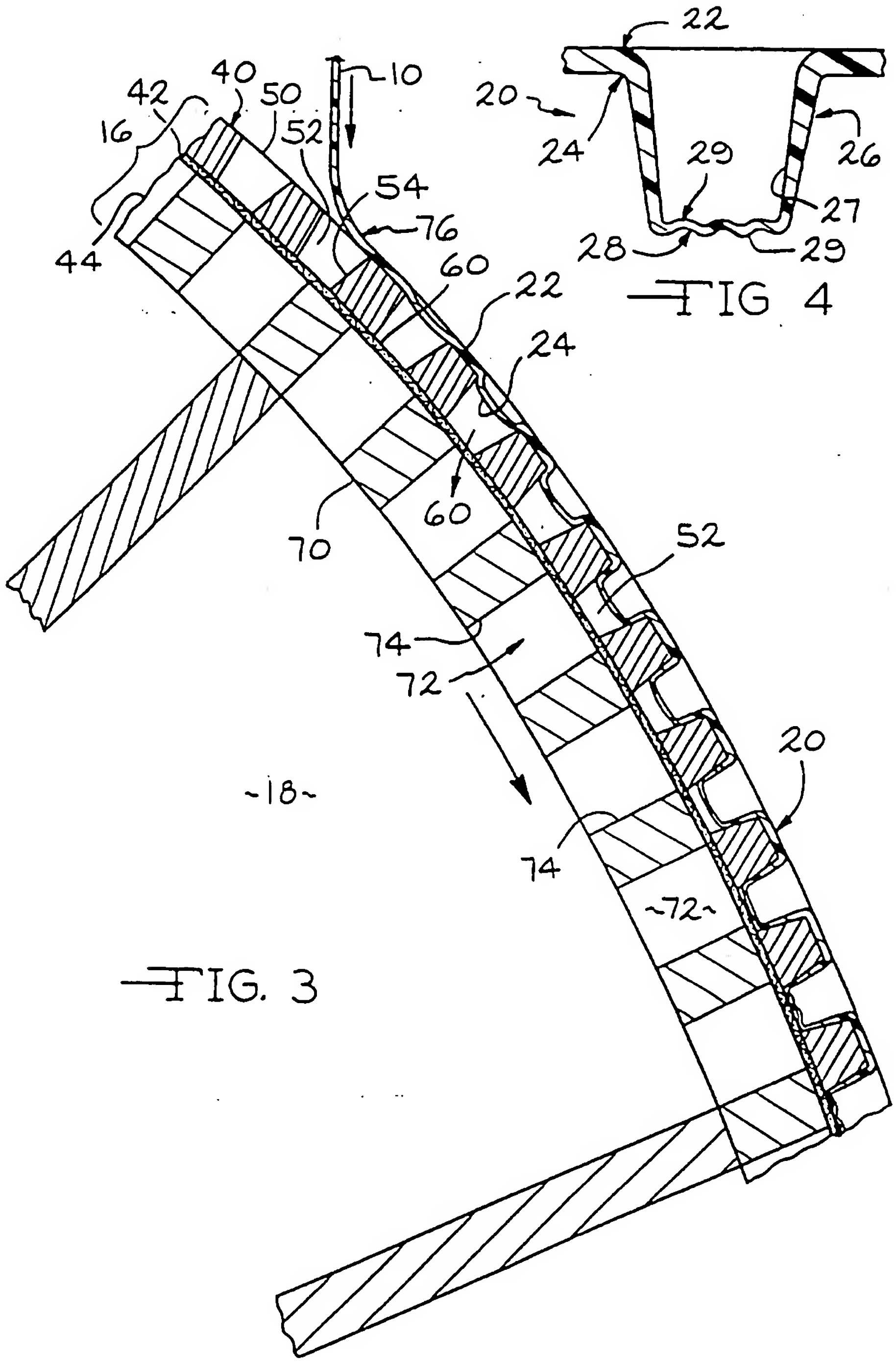
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FIG 4

42
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18
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72

FIG. 3

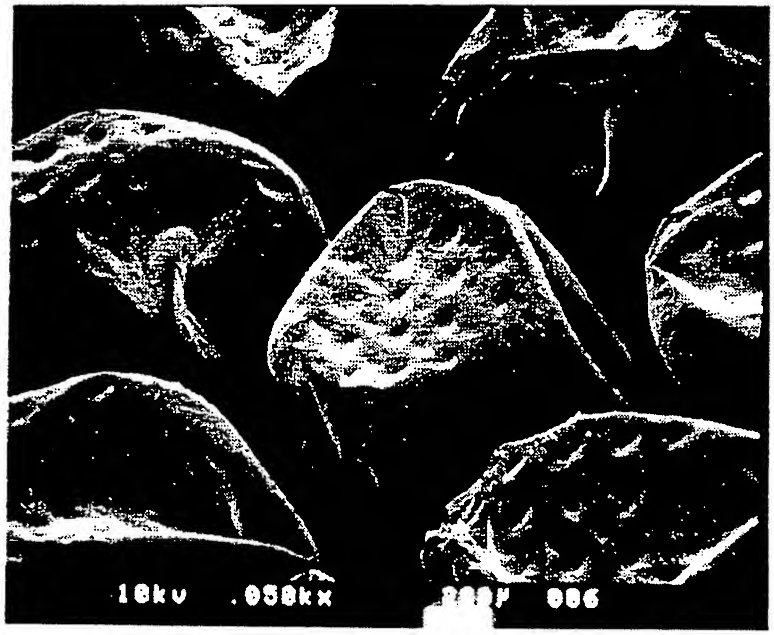

FIG. 5

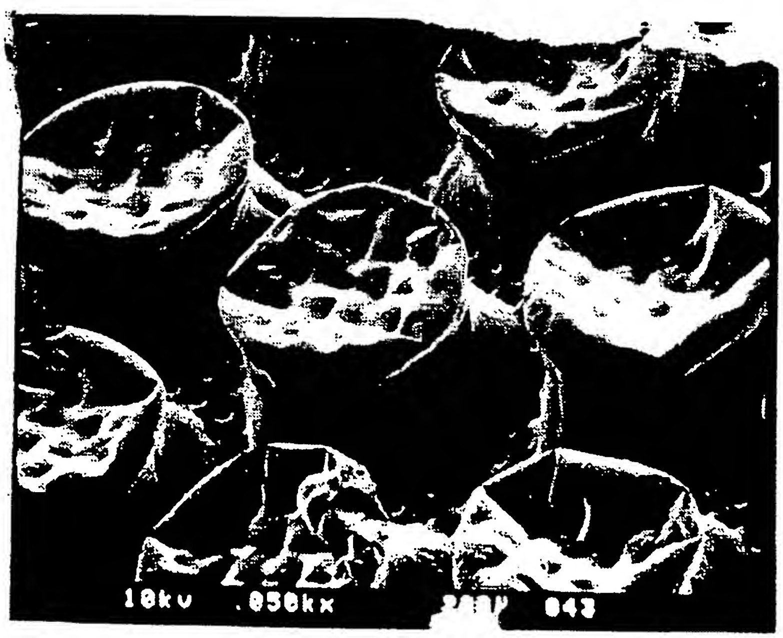

FIG. 6

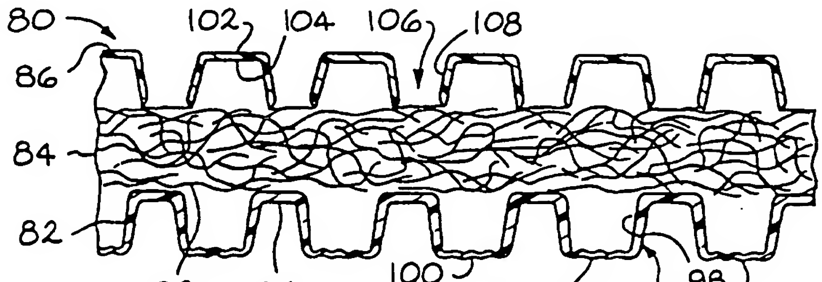

FIG. 7

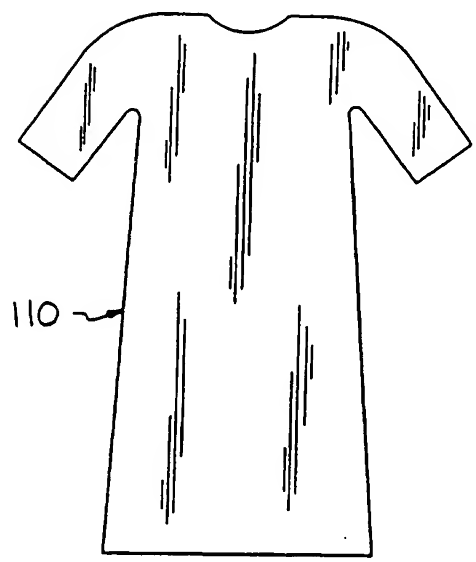

FIG. 8

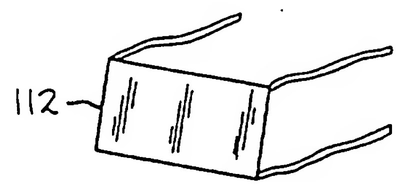

FIG. 9

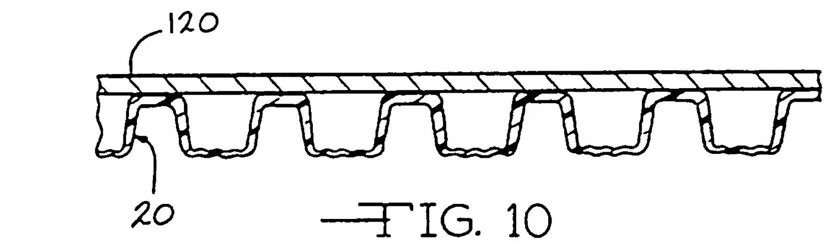

FIG. 10

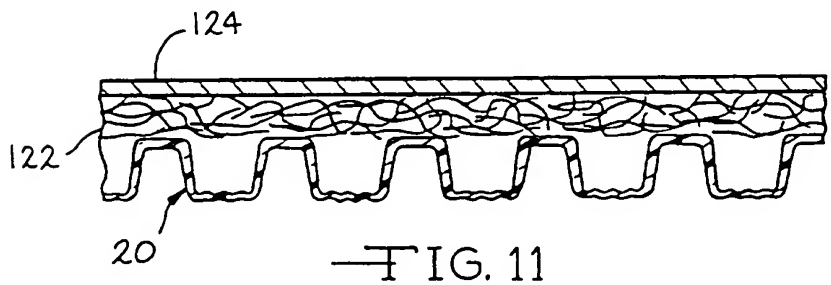

FIG. 11

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US95/13906

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :A21C 11/10; B29C 43/22; B32B 3/10, 31/04

US CL :Please See Extra Sheet.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 156/215; 264/504; 425/290, 291, 388; 428/137, 159, 213, 216, 315.5; 604/383

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

NONE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US, A, 4,644,623 (RALEY ET AL.) 24 February 1987, see entire document.	1-28
A	US, A, 3,054,148 (ZIMMERLI) 18 September 1962, see entire document.	1-28

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

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Date of the actual completion of the international search	Date of mailing of the international search report
04 JANUARY 1996	22 JAN 1996
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer BLAINE R. COPENHEAVER Telephone No. (703) 308-2351

Form PCT/ISA/210 (second sheet)(July 1992)*

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US95/13906

A. CLASSIFICATION OF SUBJECT MATTER:
US CL :

156/215; 264/504; 425/290, 291, 388; 428/137, 159, 213, 216, 315.5; 604/383